MONTHLY PROGRESS REPORT
Slurry/Micro-Surface Mix Design Procedure
August 2003

To:	**T. Joe Holland, CALTRANS**
Contract No.:	**CALTRANS 65A0151**
Contract Period:	**June 30, 2003 – Nov. 30, 2007**
Agency:	**Fugro-BRE, Inc.**
Prepared By:	**Jim Moulthrop, Principal Investigator**
Date Prepared:	**September 5, 2003**

CURRENT MONTH WORK ACTIVITIES AND COMPLETED TASKS

PHASE I LITERATURE SEARCH AND WORK PLAN DEVELOPMENT

Task 1 – Literature Review and Industry Survey

Literature Review

A list of the candidate sources for literature review was discussed at our Sacramento kick-off meeting on July 29, 2003. The research team has already acquired most of the documents on the list and efforts are being made to obtain the remaining ones. This list is presented in Table 1.

The literature search started with the review of the ASTM Standards for Slurry Seal and Microsurfacing (ASTM D 3910 and ASTM D 6372). The usual process of reviewing technical literature involves reading and summarizing the literature and preparing a report that summarizes the findings. For this project however, it was decided to take this process a step further and store all the data reviewed during the literature search in a database, for easy access and use in the later phases of the project. For the ASTM standards, all the relevant information was included in this database.

Three types of slurry are commonly used, referred to as Types I, II and III. The distinction is based on the aggregate gradation used. In addition, the different types of aggregate, mineral filler and emulsified asphalt recommended for a good slurry seal mix are specified in the ASTM standard for slurry seals (D 3910). The composition of slurry seal mixtures and the suitability of the different mix types are discussed. In the same standard, test methods for emulsified asphalt slurry seals are described. The limits or values recommended for each test were included in the database. Also the construction portion of the specification was reviewed and the important parameters entered in the database.

For microsurfacing (ASTM D 6372), the materials are based on two grading requirements, Type II and Type III. Recommendations are given for the proper use of microsurfacing and test procedures are reviewed. All pertinent information including aspects of construction were gathered and stored in the database.

Table 1. Literature Sources

Source	Available	Reviewed
ASTM D3910-98 and ASTM D6372-99 Practice for Design, Testing and Construction of Micro-surfacing	Yes	Yes
TTI Reports 0-1289-1 & 1289 2-F	Yes	In Progress
ISSA procedures for Slurry Seal Mix Design (A105) and Micro-surfacing (A143)	Yes	
International Slurry Surfacing Association Conference Proceedings	Yes	In Progress
Papers by Robert C. Benedict	Yes	In Progress
Transportation Research Board Publications, Research in Progress	No	
European Community Standards EN 12274-1, Slurry surfacing Test methods Part 1: Sampling for binder extraction EN 12274-2, Slurry surfacing Test methods Part 2: Determination of residual binder content EN 12274-3, Slurry surfacing Test methods Part 3: Consistency EN 12274-4, Slurry surfacing Test methods Part 4: Determination of cohesion of the mix EN 12274-5, Slurry surfacing Test methods Part 5: Determination of wearing EN 12274-6, Slurry surfacing Test methods Part 6: Rate of application EN 12274-7, Slurry surfacing Test methods Part 7: Shaking abrasion test in suitability of mineral aggregates to slurry mixes1 EN 12274-8, Slurry surfacing Test methods Part 8: Visual assessment1	No	
Transportation Research Laboratory Standards (UK)	Yes	
Austroads – Guide to the Selection and Use of Bitumen Emulsions	Yes	
German Standards	Yes	Yes
French Standards	Yes	Yes
CALTRANS Slurry Study	Yes	

As noted above, the Texas Transportation Institute reports are currently under review. Research Report 1289 contains specifications, usage guidelines, and quality assurance requirements for microsurfacing treatments to be applied to highway pavements.

As outlined in the proposal, the literature review will cover as a minimum the following:

- Current mix design procedures
- Laboratory tests and material physical properties
- Critical factors related to performance
- Performance of existing projects
- Existing guidelines and specifications
- Failure modes
- Benefits and limitations
- Intended use and expectations
- Constructability issues
- Thickness, age, traffic, surface conditions, climate and history

Literature Review Database

As mentioned earlier, all the data reviewed during the literature search is stored in a Microsoft Access database, for easy access and use in the later phases of the project. A description of the database follows:

The database contains information on the design, technology, and performance of slurry seals and microsurfacing analyzed in the reviewed documents. A list of the database entries is given in Tables 2 and 3:

Table 2. List of Database Entries

Field Name	Description
Mix ID	Name of mix, unique, for identification purposes
Slurry Seal/Microsurfacing	Is it a Slurry Seal or Microsurfacing
Aggregate Type	I, II, III or other
Emulsion Type	SS-1, CSS-1h or other
Binder Type	Type of asphalt binder (grade)
Mineral Filler Type	Portland cement or lime
Project Description	Description of the project
Layer Thickness	Thickness of micro/slurry
Mix Design Procedure	ISSA or other
Existing Pavement Condition	Type and amount of pavement distress before placing of micro/slurry
Environmental Conditions	Environmental conditions at the site, general and in particular during placing of the micro/slurry
Technology	Rate of application, other
Comments	Any pertinent comments

In addition to the entries in Table 2, each mix entered in the database can have an unlimited number of properties associated with it. These properties are listed in Table 3.

For each property added to a slurry seal/microsurfacing mix, its value, units, age (time) when the property was measured, and the test protocol are specified.

Note that the database is continuously adapted to accommodate all sources used in the literature search. Properties can be added at any time and even changes in structure will be made as needed. There are currently five mixes fully documented in the database corresponding to the first series of literature sources investigated.

In the later phases of the project the database could be used to investigate the effects of mix design parameters, components, technology, environment and age on the performance of slurry seal and microsurfacing treatments.

Table 3. List of Slurry/Micro Properties

Aggregate_Gradation_0.075 mm (No. 200)
Aggregate_Gradation_0.15 mm (No. 100)
Aggregate_Gradation_0.33 mm (No. 50)
Aggregate_Gradation_0.60 mm (No. 30)
Aggregate_Gradation_1.18 mm (No. 16)
Aggregate_Gradation_2.36 mm (No. 8)
Aggregate_Gradation_4.75 mm (No. 4)
Aggregate_Gradation_9.5 mm (3/8 in)
Aggregate_Metylene Blue Value
Aggregate_Sand Equivalent
Aggregate_Sand Equivalent_L.A. Abrasion Test
Aggregate_Soundness_magnesium sulfate
Aggregate_Soundness_sodium sulfate
Aggregate_Unit Weight
Asphalt_Minimum Content_Wet Track Abrasion Test
Asphalt_Ring and Ball of Residual Asphalt
Distress_Cracking
Distress_Rutting
Emulsion_Minimum Content_Wet Track Abrasion Test
Emulsion_Particle Charge
Emulsion_pH
Mineral Filler_Sieve Analysis
Mineral Filler_Type
Mix_Abrasion Loss_Classification Test
Mix_Absorption_Classification Test
Mix_Compaction_Loaded Wheel Test
Mix_Consistency Test
Mix_Cure Time_Cohesion Test
Mix_Displacement_Loaded Wheel Test
Mix_Early Rolling Traffic Time_Cohesion Test
Mix_Initial Set Time
Mix_LongTermMoistureSucept_Wet Track Abrasion Test
Mix_Pupmpability
Mix_Resildual Asphalt Content
Mix_Set Time_Cohesion Test
Mix_Stripping Resistance_Wet Track Abrasion Test
Mix_Wear Value (WTAT loss)_Wet Track Abrasion Test

Industry and Agency Surveys

Following our discussion with members of the team and CALTRANS, three surveys were designed: 1) one for agencies, using the AASHTO LISTSERVE link, 2) one for contractors and manufacturers in the United States and the international slurry surfacing and microsurfacing industry, and 3) one for the advisory panel contractors. The three proposed survey questionnaires are presented in Attachment A. At this time the research team and CALTRANS are reviewing them.

Task 2 – Work Plans for Phases II and III

During this report period, the proposal was reviewed to reacquaint the team with the original direction of the study. As a result, continuing discussions took place between Mr. Holleran and Ms. Goldman regarding a laboratory approach to the mix design process. Mr. Holleran has an extensive library of papers, some unpublished, that were developed by Mr. Ben Benedict who is considered to be the "father" of the current International Slurry Surfacing Association's design procedures. In addition, he also has acquired French standards and special tests and has reviewed them for ideas that will apply to the new mix design procedures. Ms. Goldman has begun translating several German standards and special tests. The project team will provide an extensive list of the papers and publications referred to above in the next monthly report.

A working paper outline regarding the thoughts and needs of the Phase II plan was prepared and formed the basis of discussions between the team members. Some of the key points and ideas are noted below.

The proposed tests must flow throughout the various stages of the process.

- The "process" stages are defined as:
    - Mixing
    - Placing
    - Opening to traffic
    - Curing

- Questions that define short term performance:
    - Can it be mixed?
    - Can it be placed through the spreader box?
    - How long will it take before traffic can get on the mix?

- Questions that define long term performance:
    - What is the life expectancy under project traffic and environmental conditions?

It will be important to understand and quantify the failure modes in each of the phases, such as:

- Mixing
    - Aggregate coating/adhesion.
        - Mix fails due to stripping, raveling, or delamination.
            - These types of failure can occur at any of the four stages of the process.

- Placing
    - Wet cohesion of the mix.
        - The mix needs to have sufficient total liquids to wet the pavement surface when placed, and at the same time, be a cohesive mass.
            - Delamination can occur if the mix is too dry (a design or production problem), or if the pavement surface is too open or dirty (a project selection or construction problem).

- Opening to traffic
    - Build up of cohesion and curing.
        - Cohesion of the mix is important for resisting damage by traffic.
        - Failure can occur by raveling or delamination.

- Curing
    - Mix needs to cure properly.
        - Mix fails by delaminating, raveling, cracking, stripping, or deforming.

Short Term Considerations

The types of mixing tests required should be able to discriminate between acceptable and non-acceptable mixes. For example, there is a need for a specific test that can indicate the build up of cohesion and adhesion of the mix. The current test procedure is very subjective and is not discriminating. Perhaps a torque meter can be used to take measurements. Team members have been in contact with Mr. Brad Jenkins of JETCO, a company in Duarte, CA that specializes in the design and manufacture of torque tools. One thought is to use the existing standard test for zeroing in, then use the torque requirement for minimum and maximum specification limits.

As noted above, the cohesion of the mixture is an important feature during several portions of the process because it deals with the mixing and coating characteristics of the mix. One mix test developed in Germany might be appropriate and should be evaluated. Another approach might be to modify the existing workability test.

Resistance to water damage is also important and perhaps could be evaluated by a modified Lottman test (AASHTO T-283) and using specimens prepared for cohesion testing (i.e., measuring cohesion changes as a surrogate for adhesion).

Long Term Considerations

Raveling is a cohesion issue that should be determined on aged or soaked samples with the current ISSA Wet Track Abrasion Test (WTAT). The test should be performed on both aged and un-aged samples.

Cracking can be a performance issue, particularly with stiffer mixes. Cracking potential can be inferred from fatigue tests. They can be expensive and time consuming, but they do indicate flexibility. A flexibility test for cured samples should be identified. The French developed the Frass test, which is run at various temperatures to measure flexibility. A sample is coated on a thin metal sheet, conditioned, and then bent in a mandrel until cracking occurs. Another option would be to measure modulus using a conventional universal testing machine. A standard sample configuration and conditioning procedure should be developed for this.

Deformation and rolling resistance for some slurry surfaces (especially those placed on airfield runways and taxiways) can be measured using the ISSA standard loaded wheel test that was

improved by Mr. Benedict, using a Georgia loaded wheel tester, or the newly developed Asphalt Pavement Analyzer produced by Pavement Technology Inc. of Covington, GA.

The team will continue to discuss the issues related to the Phase II and III work plans and will update our progress in the next reporting period.

It should be noted that to clarify and distinguish individual tasks as they relate to the whole project, tasks have been renumbered in consecutive order from Task 1, originating in Phase I, to Task 10 ending in Phase III, (i.e., instead of renumbering Tasks 1-3, for example, in each phase of the project). Task activities within each phase remain as originally defined.

PHASE II MIX DESIGN PROCEDURE DEVELOPMENT

Task 3 – Evaluation of Potential Test Methods
No Activity

Task 4 – Evaluation of Successful Constructability Indicators
No Activity

Task 5 – Ruggedness Tests of Recommended Equipment and Procedures
No Activity

Task 6 – Phase II Report
No Activity

PHASE III PILOT PROJECTS AND IMPLEMENTATION

Task 7 – Evaluation of Potential Test Methods
No Activity

Task 8 – Workshop Training Program/Pre-Construction Module
No Activity

Task 9 – Pilot Projects/Procedure Validation
No Activity

Task 10 – Final Report
No Activity

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below.

- Continue reviewing the documents selected for literature research and acquire the documents currently not available.

- Finalize questionnaires for agencies, industry, and the advisory panel, and publish/send to intended recipients.

- Continue development of Phase II and Phase III work plans.

ATTACHMENT A

CALTRANS PROJECT 65A0151
SLURRY AND MICROSURFACING MIX DESIGN PROCEDURES

Questions for Industry Participants

1. Do you design slurry seal and microsurfacing mixtures? If NO, thank you for your participation in this project.
   YES_____ NO_____

2. If YES, do you use the current International Slurry Surfacing Association design procedures?
   YES_____ NO_____

3. If NO, what design process do you use?
   _____

4. If YES, are there any parts of the procedure you don't use or have modified?
   _____

5. If YES, please explain.
   _____

6. In your opinion, are there any test methods and procedures that need to be revised or eliminated?
   YES_____ NO_____

7. If YES, please explain and list the method[s] or procedure[s].
   _____

8. In your opinion, do the procedures relate to performance in the field?
   YES_____ NO_____

9. If NO, please identify and explain those procedures, if any, that do relate to performance.
   _____

10. If YES, please explain and indicate the procedures that relate to performance.
    _____

11. What types of complaints do you receive from your customers? Please list them in order of Most Often to Least Often.
    _____

12. What do you try most to control, or allow for, in field operations?
    _____

CALTRANS PROJECT 65A0151
SLURRY AND MICROSURFACING MIX DESIGN PROCEDURES

Questions for AASHTO LISTSERVE Recipients

1. Do you use slurry seals or microsurfacing as a surfacing technique on your roadway system? If NO, thank you for your participation in this project.
   YES_____ NO_____

2. If YES, how much of each [approximately] have you used in the years noted below?

Year	Slurry Seal, yd^2 or tons	Microsurfacing, yd^2 or tons
2002		
2001		
2000		

3. If you use these systems, do you expect to continue to use them?
   _____

4. If you use these surfacing systems, what are your expectations regarding service life of both slurry seals and microsurfacing [how long do you expect them to last]?
   Slurry Seal_____
   Microsurfacing_____

5. Do they last as long as you expect?
   Slurry Seal:
   YES_____ NO_____
   Microsurfacing:
   YES_____ NO_____

6. Have you experienced any performance problems with slurry or microsurfacing systems?
   YES_____ NO_____

7. Are they during or after construction?
   DURING_____ AFTER_____

8. Please identify the problems with either system.
   Slurry Seal_____
   Microsurfacing_____

9. Do you perform any QA testing and evaluation on these systems?
   YES_____ NO_____

10. If YES, please describe.
    Slurry Seals_____
    Microsurfacing_____

CALTRANS PROJECT 65A0151
SLURRY AND MICROSURFACING MIX DESIGN PROCEDURES

Questions for Advisory Panel Contractors

1. Please indicate who designs your slurry seal and microsurfacing mixtures.
   Private testing laboratory?_____
   Emulsion supplier?_____
   Other? Please explain_____

2. What are the biggest areas of complaint from your customers?
   Service life_____
   Traffic time_____
   Adaptability to conditions_____
   Utility- types of roads they can be used on_____

3. Do the slurry seal and microsurfacing mix designs provided to you satisfy your requirements in terms of being able to mix, place, and finish the system? Please indicate below.
   Slurry Seal_____
   Mix_____
   Place_____
   Finish_____

   Microsurfacing_____
   Mix_____
   Place_____
   Finish_____

4. Do you make adjustments to the mix design in the field? Please indicate the reason[s] below.
   Slurry Seal_____
   Microsurfacing_____

5. Have you encountered problems reproducing the laboratory mix design in the field?
   _____
   _____

6. If yes, please explain.
   Slurry Seal_____
   Microsurfacing_____